U. S. NAVAL AIR DEVELOPMENT CENTER

JOHNSVILLE, PENNSYLVANIA

Aviation Medical Acceleration Laboratory

NADC-MA-6116 9 June 1961

The Effect of Ageing on the G-Tolerance of Rats

Bureau of Medicine and Surgery
Sub Task MR 005.15-0002.3 Report No. 5

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SUMMARY

The effect of age on the G tolerance of rats was studied in five different age groups — one, three, four, six, nine and twelve months. Each group consisted of 24 male Sprague-Dawley rats. All of the rats were subjected to 20 positive G and their survival times were measured using an EKG end point. The results show that there was a gradual decline in acceleration tolerance with increase of age in this group of 98 rats.

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INTRODUCTION

The question of the age of an animal in relation to that animal's ability to withstand positive acceleration has been raised during several experiments in this laboratory. The present study was designed, therefore, to determine if any relationship exists between age and tolerance to positive acceleration. If such a relationship were to be found , it was felt that a best range of age limits would be established for experimentation for this type of stress.

METHODS

Animals used in this experiment were male Sprague-Dawley rats from Hormone Laboratories, Chicago, Ill. All the animals were born within a few days of each other. They were divided into groups of 24 each and held in the animal colony at the Aviation Medical Acceleration Laboratory (AMAL) for varying lengths of time—1, 3, 4, 6, 9, and 12 months. They were maintained on Purina Chow with water ad libitum . Temperature in the animal house was held at 23 to 24°C. Handling was limited to weighing the animals at weekly intervals. At the end of each ageing period, the animals from one group were loosely restrained in individual cages and placed horizontally on the eight-foot radius animal centrifuge for an acceleration of 20 positive G. Heart rate was monitored by means of a transistor amplifier method (1) developed at AMAL as a means for determining the physiological end point of an animal's tolerance to acceleration. Acceleration was stopped when the animal's heart rate decreased to 2 beats per second for ten seconds, at which time it was considered dead (2). The average heart beat under resting conditions before acceleration was 6 to 8 beats per second.

Since the survival time under an acceleration of 20 positive G does not follow a normal distribution, data were analyzed by the method advanced by Litchfield, et al (3, 4) for time-percent effect curves. This method gives a close approximation to the procedure developed by Bliss (5) of using logarithmic probability transformation for biological studies except that data in their original form may be plotted directly onto logarithmic-probability paper. By means of nomographs, the parameters and confidence limits of the time-percent effect curves may be made directly from original data. As is shown in Figures 1 and 2, such transformations effect a normal distribution which becomes a straight line by plotting on probit paper.

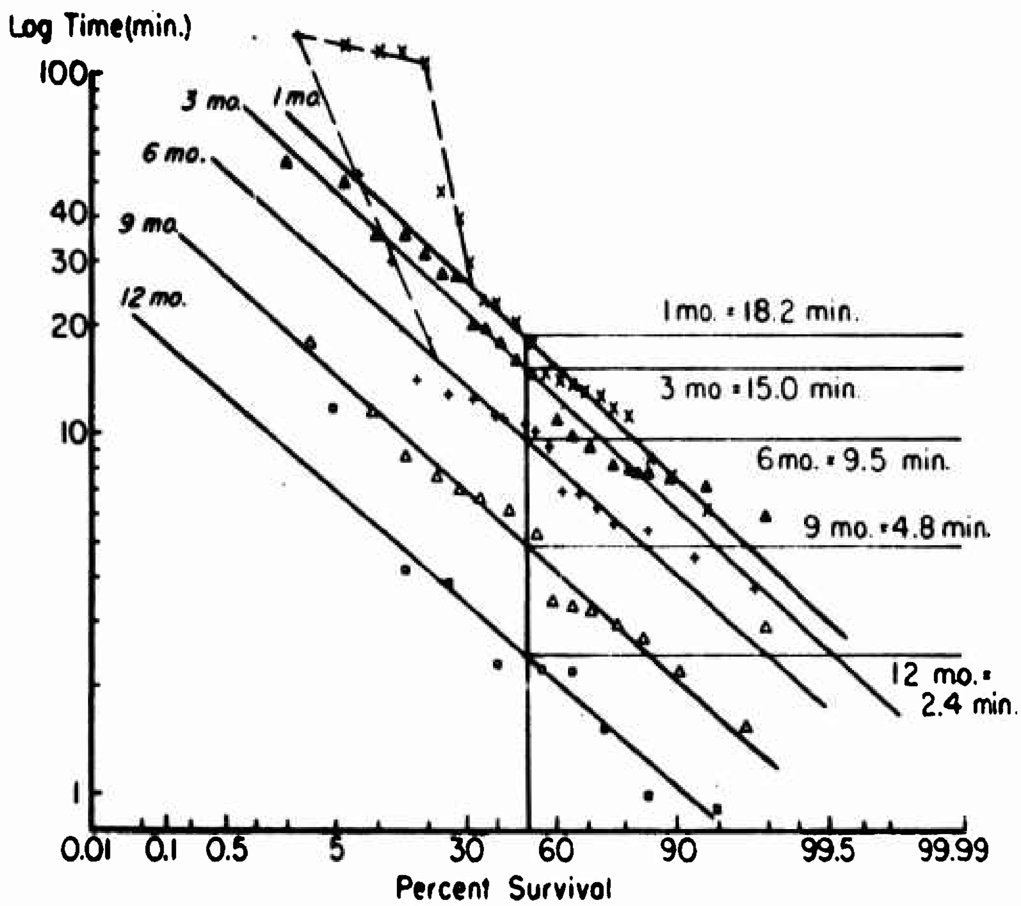

Fig. 1. Probit plot of percent survival vs. log time of age.

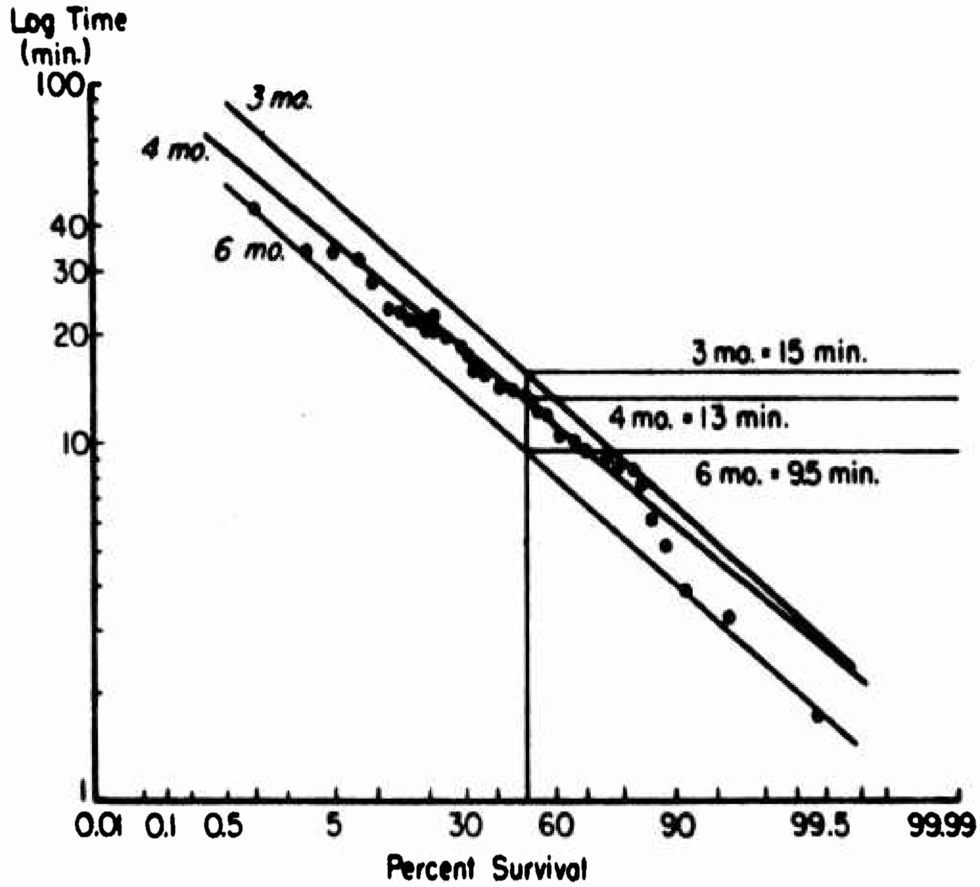

Fig. 2. Probit plot of percent survival vs. log time of 4 month group vs. 3 and 6 month group.

TABLE I

EXPERIMENTAL CONDITIONS AND COMPARISON OF SURVIVAL TIME AT 20 POSITIVE G

Age (months)	Number of Animals		$\overline{X}$ Med.	σ	$\sigma_{\overline{X}}$ Med.
	Start	End			
1	24	24	18.2	2.01	0.58
3	24	24	15.0	1.99	0.57
4	48	47	13.0	1.91	0.39
6	26	23	9.5	1.89	0.59
9	24	17	4.8	1.95	0.68
12	24	10	2.4	1.91	0.86

RESULTS

Figures 1 and 2 illustrate graphically the decline of tolerance when animals were tested at an acceleration of 20 positive G at 1, 3, 4, 6, 9, and 12 months of age. As is shown by Table I, the median survival time decreased as the age of the animal increased during this experiment (Figure 3). Rats in close age groups, i.e., 1 and 3, 1 and 4, 3 and 4, and 4 and 6, are not significantly different from each other; all other group differences are statistically significant from each other at the 0.5 level of confidence (Table II). A small aberrant group of animals with great tolerance to acceleration showed up in the 1 month group and will be further investigated.

DISCUSSION

There have been observations that tolerance to different types of stress may vary with age and/or weight (6, 7, 8, 9). McCay, et al (7, 8) found that rats on diets of restricted caloric intake lived longer than those with similar diets but ad libitum. Thus it was shown that an actual improvement in physical condition must have taken place for those on the restricted diet because they not only lived longer but proved to be more resistant to chronic diseases as well as to tumor formation, and appeared to be chronologically younger than their control group. The fact that there were deaths in the older age groups before the termination of this experiment is probably to be explained by a lessening of physical condition as well as the usual chronic rat diseases although the animals accelerated to 20 positive G had very little disease apparent at autopsy. Sellers (10) and others also have noted age or weight factors under different stresses. They found that older rats do not appear to acclimatize to cold as well as younger animals, not being able to maintain weight in the cold and probably not being able to make as complete a metabolic adjustment as younger animals do. Heroux and Hart (6) found that the survival time at -29°C was significantly correlated with individual body weight for animals which had been acclimatized to 30°C. Britton, et al (11) observed that young and nearly full-grown rats did not withstand G forces as well as mature animals and stated that there was a definite ageing factor involved. This observation however is just the opposite from that found in the present investigation. In the present study a decline in tolerance was noted with each increase of age. In addition, a group of fifty animals, four months of age and from the same supplier, which were used as controls in other experiments during this same time period, had a curve lying between the 3 and 6 month age groups (Figure 2). In rats under 6 months of age, differences between close age groups,

TABLE II

SIGNIFICANT DIFFERENCE BETWEEN AGE GROUPS

OF RATS EXPOSED TO 20 POSITIVE G.

Age (months)	1	3	4	6	9	12
1	—	—	—	+	+	+
3	—		—	+	+	+
4	—	—		—	+	+
6	+	+	—		+	+
9	+	+	+	+		+
12	+	+	+	+	+	

Probability $< .05$

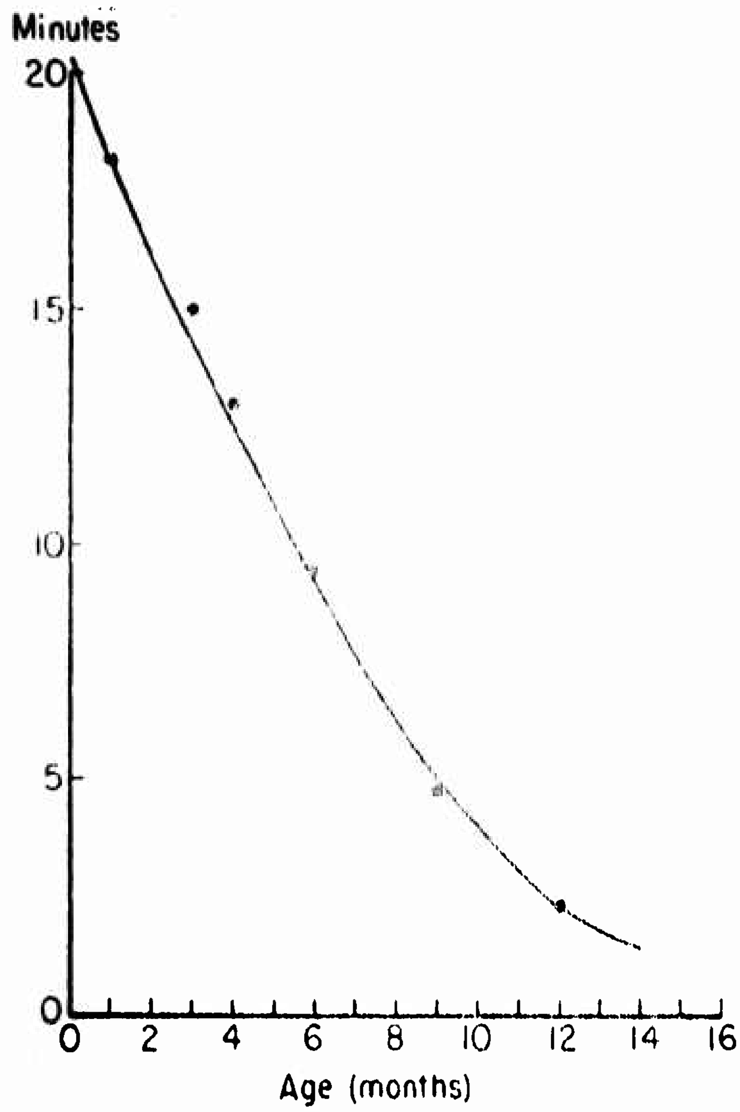

Fig. 3. Median survival time vs. age.

i.e., between 1 and 3, 1 and 4, 3 and 4, and 4 and 6 were not significant; however differences between all other age groups show significance (Table II).

This decline in tolerance to positive acceleration might be caused by any of a number of physical and/or physiological variables, such as a decrease of elasticity of tissues, decreased ability to adapt, an increased inclination to disease and subclinical infections, increase in weight and fat deposits, increase in age, length of time on diet, length of time of forced inactivity, response of the rat to different seasons of the year, actual physical pull of the visceral organs downward to restrict or inhibit respiratory movement, (12) etc. The changes in elasticity of the tissues of the body with age, particularly the cardiovascular system and the tissues of the lungs could be a deciding factor with this type of stress. On autopsy it has been found that animals which have survived long periods of exposure to 20 positive G had little congestion or hemorrhagic areas in the lungs or disturbances in their cardiovascular system. On the other hand those which succumbed had congestion, large hemorrhagic areas sometimes involving whole lobes of the lungs as well as a persistant finding of engorgement of the vena cava and right heart failure leading to eventual death, most probably due to anoxic anoxia.

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